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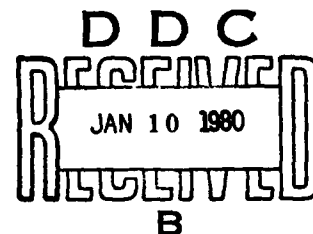
INTER-DEPOT TRANSFER MODEL



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SUMMARY

1. Background

Distribution Effectiveness has been running several points below DARCOM established targets. This is due in part to rapid changes in demand patterns which result in significant stock imbalances at the Area Oriented Depots (AODs). A manual system is available at the Materiel Readiness Commands (MRCs) for redistributing stock on hand to correct imbalances. However, the manual system has two deficiencies: slow reaction time and use of outdated tables. An automated economic asset redistribution system is a viable method to increase distribution effectiveness. The Development and Readiness Command (DARCOM) asked the Inventory Research Office (IRO) to update the tables and examine the feasibility of an automated Inter-Depot Transfer System. If the findings are positive, DARCOM asked that suitable specifications be developed for implementation in the Commodity Command Standard System (CCSS).

2. Objective

The objective of this study is to examine the feasibility of an automated economic Inter-Depot Transfer (IDT) System and, if feasible, to develop specifications for implementation in CCSS.

3. Methodology

The background model and its limitations were examined and suitable refinements were incorporated and evaluated for feasibility. Current transportation data were collected to update values of the input parameters. A set of tables, an operational computer program, and suitable specifications were developed for CCSS implementation.

4. Assumptions

A conservative system is desirable. That is, limitations should be imposed on the transfer quantities to preclude back-shipments.

Sufficient tonnage will be generated by the IDT system to qualify for bulk rates. Back-shipments and shipments to fill requisitions from a customer outside a depot complex are at standard rates.

5. Conclusions and Recommendations

A conservative, automated, economic Inter-Depot Transfer System is feasible with respect to model development, ease of implementation, operation, and system maintenance. A suitable system was developed and its implementation is recommended.

The system features several control parameters to provide management the capability to control the Inter-Depot Transfer program commensurate with the available resources and desired objectives. For example, these parameters can be used to adjust the volume of transfers up or down as is desired.

6. Implementation

The system is being developed as a stand alone system by ALMSA and will be prototyped to generate data which will be the basis for assigning numerical values to the control parameters. Current milestones call for full implementation with CCSS Release 5900.

CHAPTER I

INTRODUCTION

1.1 Background

In 1971, IRO developed under DARCOM sponsorship a model and set of tables for Inter-Depot Transfers (IDT). This was precipitated by activities related to the Vietnam conflict which resulted in zero stock balances at the East Coast depots but surplus stock at the West Coast depots. DARCOM wanted a quick and simple solution to correct serious imbalances at that time. Application was to be limited to transfers between East and West Coasts. The IRO model and tables (1) were developed under these constraints. The model and tables were authorized for use by the MRCs, but were never incorporated in CCSS.

More recently, transportation data continue to show a proportion of items with serious stock imbalances. The proportion of such items is sufficiently large to degrade distribution effectiveness for DARCOM. Concerned with this problem, DARCOM initiated action to automate economic inter-depot transfers when there are imbalances. The IRO model was to provide the economic transfer quantities. As part of this action, then, DARCOM tasked IRO to update the 1971 model and tables and develop suitable specifications for CCSS implementation.

1.2 The 1971 Model

The model computes a transfer quantity which is optimum with respect to transportation costs. It considers the advantage of transfers in bulk (lower transportation rates) and the disadvantage of transferring excessive quantities (must back-ship and pay transportation charges at less than bulk rates). The model computes the probability that a unit transferred will be used at the receiving depot and the probability that it will be used at the shipping depot (in which case a transportation charge at less than bulk rate will be incurred). Consequently, the computation fully recognizes the possibility of back-shipping and the associated cost. It considers inherent demand variability and in that respect provides a safety level for normal demand variation.

The model does not consider the impact of the transfer on supply performance. For example, a requisition from Europe is to be filled from New Cumberland Army Depot. If NCAD has no stock, stock to fill the requisition will be moved from Sharpe Army Depot (assume Red River also has zero balance) to NCAD then to the European customer. The time to move the stock from SHAD to NCAD is delay to the customer and would not be incurred if NCAD had stock. Thus, the supply performance to the customer suffered in this instance.

The model does not rigorously treat fixed cost to transfer. It is limited to two depots. Finally, the model assumes that the average forecast error is 60% for all items. This assumption was acceptable in 1971 but due to subsequent analyses of forecast error (2) and changes in CCSS, this assumption is not suitable today.

1.3 Objective

The objective of this study is to update the 1971 model and tables and examine the feasibility of implementing the model or set of tables in CCSS. If determined to be feasible, suitable specifications for implementation should be developed as part of this study.

1.4 Methodology

Initial effort centered on refinements to the 1971 model. During this effort it quickly became apparent that amplification of the model to include supply performance consideration introduces new parameters and variables. This necessitated two distinct efforts. The first effort was data collection in order to update not just the old parameter values but to develop values for the new parameters. The second effort consisted of sensitivity analyses on the variables. Having more variables meant that the number of tables would greatly increase. If the tables are to be useful, we felt that the number of tables should be kept to a minimum. The sensitivity analysis was an attempt to select the most crucial variables and to group all the possible values of a particular crucial variable into a handful of groups. In this way we could reduce the number of required tables to a manageable number.

After the above efforts we developed tables and specifications for implementation in CCSS (3). Following review of the specifications by ALMSA,

they determined that programming the model in CCSS as a FORTRAN module would be feasible and preferable to the tables. Our effort then turned to the development of an operational FORTRAN program for use in CCSS.

Throughout the course of this study, feasibility with respect to model development, ease of implementation, operation, and system maintenance was foremost. The program we developed is virtually self contained and consequently meets the feasibility objectives.

We gave up some precision and complexity in favor of simplicity. To be specific, we did not mathematically extend the 1971 model to handle three depots. Instead, we handle the third depot by an iterative process. The final product meets the feasibility objective and computes transfer quantities that are conservative, yet economic.

1.5 Report Organization

Chapter II describes the model as it is to be implemented in CCSS. Chapter III describes the data and the methodology used in developing current values for the transportation related parameters of the model. The model can be implemented in two modes: tables and FORTRAN module to yield the economic transfer quantities. Chapter IV describes the effort related to the development of the operational FORTRAN program (i.e. FORTRAN module), while Appendix A describes the effort related to the development of the tables.

CHAPTER II

INTER-DEPOT TRANSFER MODEL

2.1 Definitions

W = unit of issue weight in pounds.

r = cost per requisition short per year. This is same as the value used in the VSL/EOQ computations.

C_{sr} = transportation related cost to move one unit of an item from the shipping to the receiving depot.

$$C_{sr} = \frac{W}{2000} (L + U + (r_b)(M)), \text{ where}$$

L = average per ton loading cost at shipping depot.

U = average per ton unloading cost at the receiving depot.

r_b = average bulk transportation rate (per ton per mile) for given commodity.

M = distance in miles between shipping and receiving depot.

C_{rs} = transportation cost to move one unit of an item from the receiving to the shipping depot at less than bulk rates, or, in general, the transportation cost to move stock at less than bulk rates.

$$C_{rs} = \frac{W}{2000} (r_1)(M), \text{ where}$$

r_1 = average less than bulk transportation rate (per ton per mile) for given commodity.

F = fixed cost to transfer. This includes cost due to negotiation effort among the MRC, DESCOM and depots, fixed receiving costs, losses during transfers, etc.

t_{sr} = average time in days to move stock from the shipping to the receiving depot. It consists of the average hold time at the shipping depot and the average intransit time from the shipping to the receiving depot.

t_{rs} = average time in days to move stock from the receiving to the shipping depot. It consists of the average hold time at the receiving depot and the average intransit time from the receiving depot to the shipping depot.

S = average requisition size. This is the same as used in the VSL/EOQ computations.

K = number of units to be transferred.

$P_1(K)$ = probability that when the K^{th} unit is transferred, it will be used to fill a requisition from a customer in the receiving depot complex.

$P_2(K)$ = probability that when the K^{th} unit is transferred it will be used to fill a requisition from a customer in the shipping depot complex. That is, $P_2(K)$ is the probability of backshipping the K^{th} unit, which may be necessary due to imperfect demand forecasting.

2.2 Assumptions:

We assume that the transportation cost for transfers will be at bulk rates, while the cost for backshipping and filling requisitions from the wrong depot (i.e. stock level at the depot complex of the customer is zero but the requisition is filled from stocks of another depot complex) is at less than bulk rates. Since IDTs will be semi-annual and the whole stock fund catalog will be examined, it is expected that the transfer volume to be generated will be sufficient to qualify for bulk rates.

We examined the criticality of this assumption and found it to be not critical. That is, the computed economic transfer quantities are very close for the cases when we make this assumption and the corresponding cases when less than bulk rates are charged for transfers. This is because the supply performance element in the cost and saving equations is dominant.

We also assume that avoidance of backshipments is highly desirable. This is achieved by built in limits on the transfer quantity.

2.3 The Model

If we transfer the K^{th} asset and use it at the receiving depot, we save a transportation cost C_{rs} and avoid a supply performance cost equal to

$\frac{(\lambda)(t_{sr})}{(365)(S)}$. Since the probability of using the K^{th} asset at the receiving depot is $P_1(K)$, the marginal saving is

$$\text{MARGINAL SAVING} = [C_{rs} + \frac{(\lambda)(t_{sr})}{(365)(S)}] P_1(K) \quad (1)$$

The cost to transfer the K^{th} unit is C_{sr} . If we must use the K^{th} asset to fill a requisition from a customer in the shipping depot complex before we use it to fill a requisition from the receiving depot customer, we will incur additional costs. These costs are the transportation cost for backshipping which equals C_{rs} times the probability of backshipping, and the supply performance cost which equals $\frac{(\lambda)(t_{rs})}{(365)(S)}$ times the probability of backshipping. Thus, the marginal cost for the K^{th} transfer unit is

$$\text{MARGINAL COST} = C_{sr} + [C_{rs} + \frac{(\lambda)(t_{rs})}{(365)(S)}] P_2(K) \quad (2)$$

It is economical to transfer the K^{th} unit as long as the marginal saving computed by equation (1) is not less than the marginal cost computed by equation (2). However, it is not economical to transfer if the net saving for transferring the K units does not offset the fixed cost F . Thus, we would transfer only if

$$\begin{aligned} \text{NET SAVING} &= [C_{rs} + \frac{(\lambda)(t_{sr})}{(365)(S)}] \sum_{j=1}^K P_1(j) - (K)(C_{sr}) \\ &\quad - [C_{rs} + \frac{(\lambda)(t_{rs})}{(365)(S)}] \sum_{j=1}^K P_2(j) \geq F \quad (3) \end{aligned}$$

2.4 Application of the Model

2.4.1 Model Parameters

The probabilities $P_1(K)$ and $P_2(K)$ are derived in (1). The values depend on the nature of the demand distribution in the receiving and shipping depots, as well as the mean and variance of demand for each depot. We assume negative binomial distribution of demand in each depot. The mean for each depot is the product of the forecasted world wide average monthly demand (AMD) and the percent of demands satisfied from the given depot.

The variance is computed as is presently done for the VSL/EOQ routine during the RDES process.

The parameters λ and S are assigned the same values as in the VSL/EOQ process. Values for the parameters C_{rs} , C_{sr} , t_{rs} and t_{sr} were developed from current transportation data as is discussed in the next chapter.

2.4.2 Limits on the Transfer Quantity

a. The minimum transfer quantity must be the equivalent of one month's supply for the receiving depot. If the computed transfer quantity is less, nothing will be transferred for the item.

b. The maximum transfer quantity cannot be greater than the receiving depot's net requirement in the time horizon. Time horizon (TH) is by definition the period which is the difference between the procurement due in date and the current date (i.e. the date of the transfer review). Net requirement is the forecasted receiving depot demand during the TH less its assets on hand.

c. Only assets in excess of the shipping depot's requirement (which includes a safety level) in the time horizon will be considered for potential transfer.

d. The maximum time horizon is 12 months.

e. Computed net saving for a given receiving depot must not be less than the fixed cost to transfer (F). If it is, nothing will be transferred to that depot.

2.4.3 Control Parameters

There are four control parameters which provide management the capability to control this program commensurate with the available resources and desired objectives. The first parameter is the depot on hand asset position. An item will not be a transfer candidate if its on hand asset position at each of the three AOD depots is greater than some specified minimum amount. The second control parameter is the world wide on hand asset position. No item will be a transfer candidate if the on hand stock for the MRC is below some specified minimum level. The other two control parameters relate

to the limits on the transfer quantity. A safety level control parameter is used to control the amount of stock to be retained at the shipping depot. For example, if this parameter is set to 2, then the program will leave in the shipping depot assets equal to the forecast of the shipping depot's demand in the time horizon plus two months safety level. Only assets above this requirement will be considered for transfer. The last control parameter is the time horizon. No stock will be transferred in excess to the receiving depot's need in the time horizon or below the shipping depot's need in the time horizon.

2.5 Note on System Design

Values for each control and management parameter are inputs. Application of assets (i.e. determine existence of imbalance conditions, nominate candidate items for transfer, designate shipping and receiving depots, compute limits on transfer quantities) and computation of the economic transfer quantities will be done within a FORTRAN module. Another module will generate the reports. This design is easy to implement, operate and maintain.

CHAPTER III

TRANSPORTATION RELATED PARAMETERS

3.1 The "C" Parameters

To compute the "C" parameters we need average transportation charges, distances between depots, and loading/receiving costs.

3.1.1 Average Transportation Charges

Average transportation charges for the Army were provided by HQ, Military Traffic Management Command (4). These charges are summarized in Table I below:

TABLE 1: TRANSPORTATION CHARGES FOR ARMY

COMMAND	COMMODITY	LESS THAN TRUCKLOAD (< 10,000 lbs)	TRUCKLOAD (> 10,000 lbs)
(TARCOM)	Vehicles	0.273 per ton mile	0.106 per ton mile
(TSARCOM)	Machinery	0.190	0.079
(MICOM, CERCOM)	Electrical Equipment	0.198	0.106
(TARCOM)	Internal Comb. Engines	0.171	0.069
(TSARCOM)	Airplane/ Aircraft	0.275	0.155
(ARRCOM)	Ordnance	0.445	0.077

The data are for 4th quarter FY78. Data for other quarters were not readily available. We were initially skeptical about developing values for the "C" parameters based on one quarter of data. However, experimentation with the model revealed that results were not too sensitive to these parameters and ball park estimates would be adequate (see Appendix A). Furthermore, review of data in (5) revealed that we would be in the ball park because changes in the rates are not excessive from quarter to quarter. This is shown in the table below. The rates are averages over all customers and all shipments.

COMMODITY	RATES FOR 2nd QTR FY78	AVG RATES FOR 1st & 2nd QTR FY78
Vehicles	\$0.090 per ton mile	\$0.088 per ton mile
Machinery	0.096	0.099
Electrical Equipment	0.154	0.147
Int. Comb. Engines	0.144	0.101
Airplane/Aircraft	0.250	0.230
Ordnance	0.103	0.113

3.1.2 Distances Between AOD Depots

Distances between the AOD depots were taken from official tables (6). These are:

Between SHAD and NCAD: 2739 miles

Between SHAD and RRAD: 1812 miles

Between NCAD and RRAD: 1212 miles

3.1.3 Load and Receive Costs

The following load and receive costs for 4th quarter FY78 were obtained from DARCOM.

Installation	Ship Cost	Receive Cost
New Cumberland Army Depot	\$ 6.58 per ton	\$13.49 per ton
Red River Army Depot	27.23	48.15
Sharpe Army Depot	43.79	72.42

Differences in the costs among the AODs are too large to be attributable to local labor market and operating procedures. The large differences suggest that there may be no standard methodology for computing these costs, or else the methodology is incorrect.

At this point we decided not to use the ship and receive costs from the above mentioned report. Since the actual costs may be low or high, we decided that use of a high value for all three depots is better because it is conservative and precludes back-shipments. That is, by using a high

value for the sum of ship plus load cost we would not transfer in marginal situations. For purposes of estimating the "C" parameters we decided to use the Sharpe Army Depot costs but rounded the sum to \$120.

3.1.4 Estimation

Using the above data we estimate the "C" parameters for a specified MRC and ship-receive depot pair as follows:

$$C_{sr} = \frac{W}{2000} [120 + \text{DISTANCE} \times \text{TRUCKLOAD RATE}]$$

$$C_{rs} = \frac{W}{2000} [\text{DISTANCE} \times \text{LESS THAN TRUCKLOAD RATE}]$$

For example, for TSARCOM the C_{sr} and C_{rs} parameters for transfers between Sharpe and New Cumberland are:

$$C_{sr} = \frac{W}{2000} [120 + (2739) (\frac{.079 + .155}{2})] = (\frac{W}{2000}) (440)$$

$$C_{rs} = (\frac{W}{2000}) (2739) (\frac{.190 + .275}{2}) = (\frac{W}{2000}) (637)$$

Note that for TSARCOM we averaged the transportation charges corresponding to Machinery and Airplane/Aircraft. For TARCOM we averaged the charges corresponding to Vehicles and Internal Combustion Engines. The parameters for CERCOM and MIRCOM are the same because the rates for electrical equipment applies to both and there is no other applicable commodity group for them. The parameters for ARRCOM were based on the rates for Ordnance. The computed costs for all Commands and all ship-receive depot pairs are summarized in the table given in Section 3.3.

3.2 The "t" Parameters

3.2.1 Introduction

The "t" parameters represent the average time in days saved when stock is at the right depot. For example, a requisition from a customer in Europe would normally be filled from stocks held at NCAD. If NCAD stocks are at a zero balance (and assume they are zero at RRAD also), the requisition will be filled from SHAD stocks. In doing so, the stock moves from

SHAD to the requisitioner (a customer in Europe in this case) through NCAD. The time to move the stock from SHAD to NCAD is the "intransit" delay to the customer when his depot complex has zero stock balances. Practice at the depots is to hold back the shipment for a while for purposes of consolidation. Thus, the average "hold time" is also a delay. The sum of the "hold" delay and "intransit" delay is the time saved when the stock is at the customer's depot complex when his requisition is processed. This saving can be costed out and is in our model (See Chapter II).

Estimation of the average delay is complicated by the fact that stock is used to satisfy requisitions from both domestic and overseas customers. For example, the intransit delay for an overseas customer is the time to move stock from one AOD (the one with stock) to another (the AOD with no stock but in the customer's depot complex). However, for a domestic customer the intransit delay is the time to move the stock from one AOD to the processing point for that customer less the time to move the stock from the AOD in the customer's depot complex to the customer's processing point. Thus, to estimate the "t" parameter we must know for both the shipping and receiving depot the average hold times, average intransit times for domestic customers, the average intransit times for overseas customers, and the proportion of requisitions that are from domestic or overseas customers.

3.2.2 The Model for t

The model we used to estimate the t parameters is the following:

$$t = P_d(H_s - H_r) + P_o H_s + P_d(i_{ds} - i_{dr}) + P_o i_o$$

where

t = average days saved when stock is at right depot.

i_o = average intransit time in days from shipping depot to receiving depot when customer is overseas.

i_{dr} = average intransit time in days from receiving depot to processing point for domestic customer.

i_{ds} = average intransit time in days from shipping depot to processing point for domestic customer.

P_d = proportion of lines for receiving depot from domestic customers.

P_o = proportion of lines for receiving depot for overseas customer. $P_o = 1 - P_d$

H_R = Average hold time in days for receiving depot.

H_S = Average hold time in days for shipping depot.

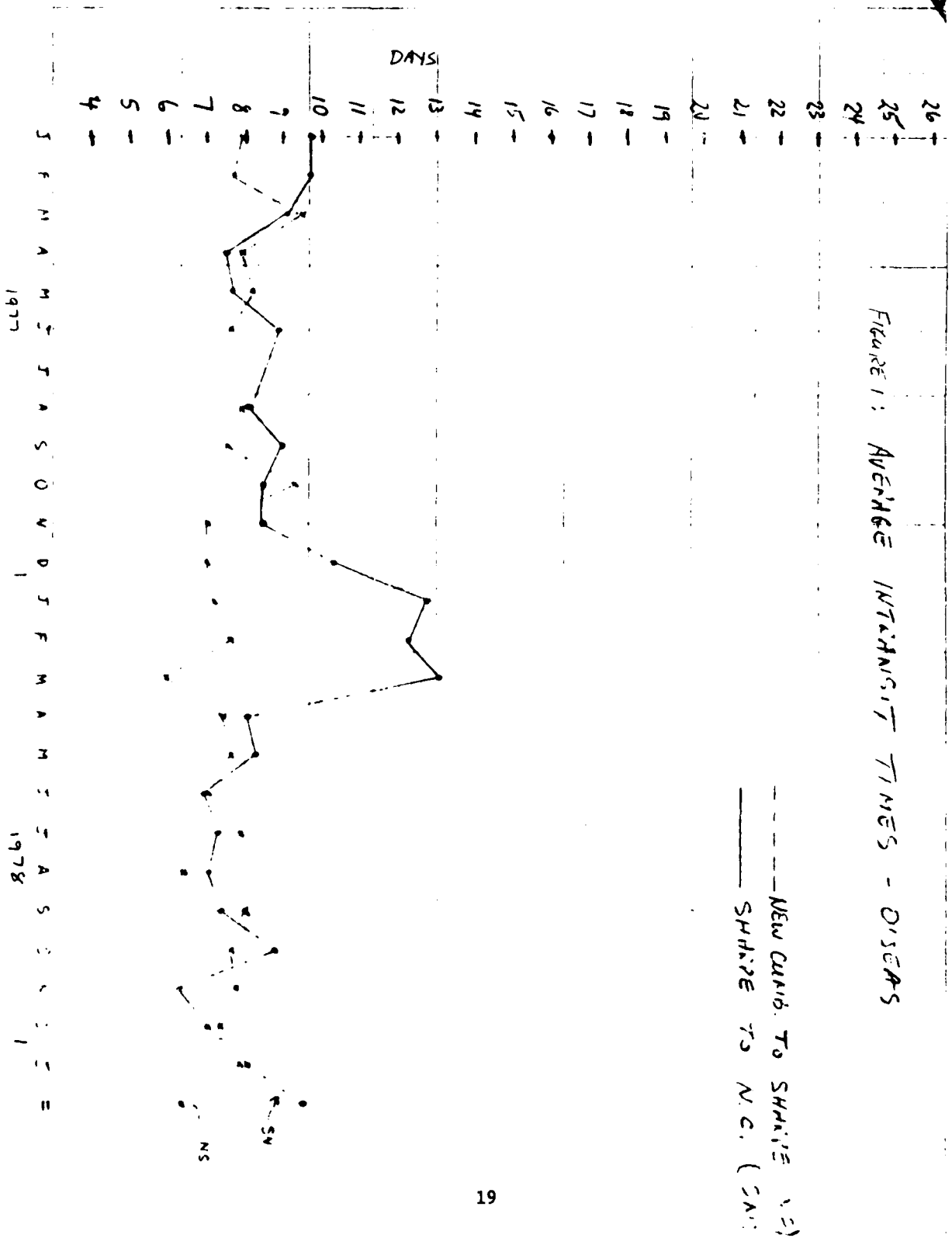
3.2.3 Data Sources

The average hold times were estimated from MILSTEP data provided by LSSA (7). The data consisted of monthly statistics (Feb 78 thru Feb 79) on number of lines processed and average hold times broken out by IPG groups and the three AOD depots. We computed the weighted average for all observations for a given AOD. The results were 1.4 days for New Cumberland, 1.8 days for Sharpe and 3.4 days for Red River. For those interested, the number of observations were 1,177,615 for NCAD, 990,970 for RRAD, and 528,525 for SHAD.

The remaining variables in the t model were estimated from DSS/ALOC Performance Evaluation Data (8). We collected monthly reports covering the period Jan 1977 through Feb 1979. For each depot, P_d was the proportion of lines shipped to FORSCOM and TRADOC customers. Domestic in-transit times were based on observations for these two customers. For all intransit times (i.e., i_o , i_{dr} , i_{ds} for each depot) weighted averages were computed. Obvious outlier observations were excluded from the data base. For example, Figure 1 shows a typical time series pattern. In this instance, we excluded the observations for Jan 78, Feb 78 and Mar 78 for the Sharpe to New Cumberland shipments (solid line).

The results of our computations are given below:

FIGURE 1: AVERAGE INTENSITY TIMES - DISCAS



		INTRANSIT TIMES		HOLD TIMES	P _d
		DOMESTIC	OVERSEAS		
New Cumberland					
From NCAD		5.2 days		1.4	
SHAD		10.4	8.0	1.8	.223
RRAD		5.8	4.9	3.4	.219
Sharpe					
From SHAD		8.2		1.8	
NCAD		12.1	7.5	1.4	.318
RRAD		10.7	5.0	3.4	.346
Red River					
From RRAD		3.2		3.4	
NCAD		6.7	13.5	1.4	.975
SHAD		8.5	12.8	1.8	.966

The above table shows, for example, that domestic shipments to CRP East (New Cumberland area) take 5.2 days from NCAD, 10.4 days from SHAD, and 5.3 days from RRAD. It also shows that 22.3% of the transfers from SHAD to NCAD are for domestic use. Average hold time for SHAD is 1.8 days.

3.2.4 Estimation

Using the model for t we enumerate below for the different ship-receive depot pairs.

$$t = P_d(H_s - H_r) + P_o H_2 + P_d(i_{ds} - i_{dr}) + P_o i_o$$

(1) New Cumberland to Sharpe

$$\begin{aligned} t &= .318(1.4 - 1.8) + .682(1.4) + .318(12.1 - 8.2) + .682(7.5) \\ t &= - .1272 + .9548 + 1.2402 + 5.115 \\ t &= 7.1828 \end{aligned}$$

(2) Sharpe to New Cumberland

$$\begin{aligned} t &= .223(1.8 - 1.4) + .777(1.8) + .223(10.4 - 5.2) + .777(8.0) \\ t &= + .0892 + 1.3986 + 1.1596 + 6.216 \\ t &= 8.8634 \end{aligned}$$

(3) Red River to Sharpe

$$t = .346(3.4-1.8) + .654(3.4) + .346(10.7-8.2) + .654(5.0)$$

$$t = + .5536 + 2.2236 + .865 + 3.27$$

$$t = 6.9122$$

(4) Sharpe to Red River

$$t = .966(1.8-3.4) + .034(1.8) + .966(8.5-3.2) + .034(12.8)$$

$$t = - 1.5456 + .0612 + 5.0232 + .4352$$

$$t = 3.974$$

(5) New Cumberland to Red River

$$t = .975(1.4-3.4) + .025(1.4) + .975(6.7-3.2) + .025(13.5)$$

$$t = - 1.95 + .035 + 3.4125 + .3375$$

$$t = 1.835$$

(6) Red River to New Cumberland

$$t = .219(3.4-1.4) + .781(3.4) + .219(5.8-5.2) + .781(4.9)$$

$$t = .438 + 2.6554 + .1314 + 3.8269$$

$$t = 7.0517$$

3.3 Final Results

Results for the C-t parameters are summarized in Table 2 below. The table values for C_{sr} and C_{rs} should be multiplied by W/2000 prior to use in the IDT model. Note that for a given ship-receive depot pair the t_{sr} and t_{rs} values are the same for all MRCs.

TABLE 2: C-t PARAMETERS

SHIPPING DEPOT	RECEIVING DEPOT			MIRCOM CERCOM	TARCOM	TSARCOM	ARRCOM
		t_{sr}	t_{rs}	C_{sr}	C_{sr}	C_{sr}	C_{sr}
				C_{rs}	C_{rs}	C_{sr}	C_{rs}
Red River	New Cumb.	7.0517	1.835	248	226	262	213
				240	269	282	539
	Sharpe	6.9122	3.974	312	278	332	260
				359	402	421	806
Sharpe	New Cumb.	8.8634	7.1828	410	360	440	331
				542	608	637	1219
	Red River	3.974	6.9122	312	278	332	260
				359	402	421	806
New Cumb.	Red River	1.835	7.0517	248	226	262	213
				240	269	282	539
	Sharpe	7.1828	8.8634	410	360	440	331
				542	608	637	1219

CHAPTER IV

FORTRAN MODULE

5.1 Module Description

The Fortran Module is an operational computer program that computes the optimum transfer quantities according to the IDT model of Chapter II. The program uses all of the variables in the IDT model and in that respect gives more precise answers than the tables developed in Appendix A. Inputs to the model are:

- a. Purpose A/Condition A on hand assets in complex of each of the three AOD depots (A_j).
- b. Demand distribution for the three AOD depots (L_j).
- c. Time Horizon for each of the three AOD depots (TH_j).
- d. Forecast World Wide Average Monthly Demand (AMD).
- e. Average Requisition Size (S)
- f. Lambda (λ)
- g. Unit of Issue Weight in pounds (W).
- h. Unit of Issue Cube (C)
- i. Values for 4 management control parameter. (See Section 4.2 and 4.3 in Chapter II). The control parameters are for world wide assets (CPWWA), depot assets (CPDEPA), time horizon (CPTH), and safety level months for shipping depot (CPSLM). For example, if CPWWA is set to 6, the program will bypass all items that have less than 6 months of world wide assets. If CPSLM = 2, the program will reserve 2 months of shipping depot assets in addition to its need in the time horizon.

The module computes the net asset position and average frequency for each depot to be

$$N_j = A_j - (D_j)(AMD)(TH), \text{ where}$$

$$TH = (TH_1 + TH_2 + TH_3)/3$$

$$DF_j = (D_j)(AMD)(12)/S$$

It selects the shipping depot to be the depot with the best net asset position, and the prime receiving depot is the depot with the worst net asset position. The remaining depot is designated to be secondary potential receiving depot if its net asset position is negative. Note, however, that this is done only after the stock positions are screened against the control parameters (i.e. net stock in a given depot must be less than some specified amount, and the world wide asset position must be no less than some specified amount).

The module then computes the maximum and minimum quantity that could be transferred and uses the IDT model to enumerate the optimum transfer quantity. If the optimum is less than the minimum, or not sufficient to offset the fixed cost to transfer, the value is set to zero and nothing will be transferred.

After the computations for the prime receiving depot, results are applied and computations performed for the second receiving depot if there is one. Thereafter the output is passed on to another module for producing reports.

The C-t parameters incidentally given in the table at the end of Chapter III are in a separate input file and are not part of this module. They are passed on to the Fortran Module along with the inputs delineated above. This permits possible future updates of the C-t parameters and implementation by mere substitution of the external C-t data file.

A listing of the Fortran Module is in the Appendix. In that listing one will note that the C-t array for TARCOM is a part of the Fortran Module. This is for test purposes only.

5.2 Validation

The IDT model assumes the negative binomial distribution for demand. For enumerating this in the Fortran Module we adopted the procedure which already exists in CCSS. That procedure makes use of a Normal approximation to the negative binomial. We did experiments to thoroughly test the CCSS approximation and found that it gives excellent results for diverse demand patterns.

We performed numerous experiments to fully test the operation of the Fortran Module. For each factor that appears in the IDT model, we took very low, very high, and intermediate values to cover even the most abstract situations. In this way we were able to fully debug the program.

APPENDIX A

DEVELOPMENT OF IDT TABLES

A.1 Introduction

The tables developed in 1971 have three factors: CRATIO, N-MONTHS and PCER. CRATIO is the ratio of C_{rs}/C_{sr} . N-MONTHS is the world wide on hand asset position for an MRC expressed in months of supply. PCER is the percent of demand that is satisfied from the receiving depot stocks.

We introduced new factors in the IDT model in Chapter 2. They are the unit of issue weight (W), average order size (S), λ , t_{sr} , t_{rs} . In addition, since we adopted the present CCSS procedure for estimating variance, the demand frequency (DF) is a factor.

We cannot have our new tables depend on all these factors because this would require too many tables. In this Appendix, we describe the experiments we did and approximations made to reduce the number of required tables.

A.2 Sensitivity Analysis

A.2.1 The t Parameters

If the difference between t_{sr} and t_{rs} is not significant, we could use the same table for a selected depot pair. For example, we could use the same table to determine the optimum transfer quantity from Sharpe to New Cumberland as from New Cumberland to Sharpe. We made numerous runs to determine if the difference between the t_{sr} and t_{rs} values is significant and found that it is. For example, for N-MONTHS = 9, PCER = .15, DF = 30 we would move 62% of the receiving depot's estimated need in the time horizon from Sharpe to New Cumberland but only 30% from New Cumberland to Sharpe.

Based on the above finding, we must have a table for each shipping-receiving depot pair.

A.2.2 Demand Frequency (DF)

For purposes of computing demand variability in CCSS, DF values are divided into seven groups. Our experiments showed that although the impact of DF on the optimum transfer quantities was great, we could reduce

the DF groups to three and use linear interpolation for any DF value in between.

A.2.3 PCER

Experiments indicated that we could give results for PCER = .1, .5, and .9 and use linear interpolation for other values

A.2.4 N-MONTHS

We found that this factor could be eliminated if the table output is changed from optimum months of supply to transfer to percent of N-MONTHS to transfer. Thus, to determine the transfer quantity, we would multiply the table entry by N-MONTHS and the demand rate for the receiving depot.

A.2.5 The Bulk Rate for Transfer Assumption and the "YZ" Factor

We have not yet addressed the impact of C_{rs} , C_{sr} , λ , S , W on the optimum transfer quantity. In this section we develop a new factor, "YZ", to replace these five factors. In doing this, we relax the bulk rate assumption.

From our model in Chapter 2 the optimality condition is

$$(1) \quad \left[\frac{W}{2000} C'_{rs} + \frac{(t_{sr})}{(365)(S)} (\lambda) \right] P_1(K) \geq \frac{W}{2000} C'_{sr} + \left[\frac{W}{2000} C'_{rs} \frac{(t_{rs})}{(365)(S)} (\lambda) \right] P_2(K)$$

In the above equation C'_{rs} and C'_{sr} correspond to the C_{rs} and C_{sr} values given in Table 2, Chapter 3. Dividing Equation (1) by $\frac{W}{2000} C'_{sr}$ gives

$$(2) \quad \left[\frac{C'_{rs}}{C'_{sr}} + \frac{(2000)(t_{sr})}{(365)(C'_{sr})} \frac{(\lambda)}{(W)(S)} \right] P_1(K) \geq 1 + \left[\frac{C'_{rs}}{C'_{sr}} + \frac{(2000)(t_{rs})}{(365)(C'_{sr})} \frac{(\lambda)}{(W)(S)} \right] P_2(K) \geq 0$$

We now make two approximations:

a. $\frac{2000}{(365)(C'_{sr})}$ is equal to .01. This approximation assumes that C'_{sr} is equal to 548. From Table 2, Chapter III the maximum value for C'_{sr} is 440. Consequently, for our parameter values this term is always greater than .01. For sake of simplicity we set this term to .01. In doing this we are being conservative since the result is to transfer less.

b. $C'_{rs}/C'_{sr} = 1$. We make this approximation again for sake of simplicity but it is fully justifiable. Our experiments show that if $(.01)(t)(\lambda)/WS$ is 8 or larger, the C'_{rs}/C'_{sr} term is insignificant. That is, setting C'_{rs}/C'_{sr} to 1, 2, 3 or its maximum value of 4 (see Table 2, Chapter III) has very little impact on the optimum transfer quantity. When $(.01)(t)(\lambda)/WS$ decreases from 8 to 1, the impact of C'_{rs}/C'_{sr} becomes increasingly greater. The effect of setting C'_{rs}/C'_{sr} to 1 in all cases is to transfer less than we should when $(.01)(t)(\lambda)/WS$ is less than 8, but the effect is negligible otherwise. We make this approximation because we expect very few secondary ASF items to have $(.01)(t)(\lambda)/WS$ values less than 8 and should an item fall in this category, the consequences of the approximation are minor.

Note that by making approximation b. we are relaxing the bulk rates for transfer assumption. In effect, we are now assuming that the per ton mile charges for transfer (includes transportation charges, load and receive costs) are the same as the per ton mile charges (includes only transportation costs) for small shipments. Stated another way, we are now assuming that by transferring in bulk, the saving in transportation cost is just sufficient to offset the load and receive cost to transfer.

Now let $YZ = \lambda/WS$. Substituting this and approximations a. and b. in equation (2) gives

$$(3) \quad [1 + (.01)(t_{sr})(YZ)]P_1(K) \geq 1 + [1 + (.01)(t_{rs})(YZ)]P_2(K)$$

This is now the equation of optimality and the λ, W, S, C_{sr} and C_{rs} factors have been reduced to just one factor. Sensitivity analysis on YZ revealed that we transfer more as YZ increases. However, we can limit the YZ factor to 6 values (10, 30, 50, 90, 200, 1000) and use linear interpolation for any YZ value in between.

4.2.6 The Time Horizon (TH)

By definition, time horizon is a planning period equal to the difference between the date of a significant due in and the date of review for possible transfer divided by 30 (i.e. TH is expressed in months).

We performed experiments to determine how we would distribute world wide assets when the actual time horizon is greater than N-MONTHS (i.e. the world wide assets expressed in months of supply). For N-MONTHS of 5 we looked at a time horizon (TH) equal to 4,5,6,7,8 and 14. For N-MONTHS of 11 we examined TH equal to 10,11,12,13,14 and 20. We did this for low and high YZ values and low and high DF values. Our results were consistent: the value of the optimum transfer quantity is not sensitive to TH. How much we transfer depends on the receiving depot's share of demand (i.e. PCER), the demand frequency (DF), and the YZ parameter, but not on TH.

A.3 Final Results

We developed six tables, one for each shipping-receiving depot pair. Inputs to the tables are:

- a. D - this is the % demand filled from stocks in potential receiving depot.
- b. $YZ = \lambda / (W)(S)$, where W is the unit of issue weight, S is the average requisition size (this is same as value used for VSL/EOQ input), and λ is the same as the value for VSL/EOQ input.
- c. DF - this is the annual frequency of demand. It is equal to the world wide average yearly demand divided by the average requisition size.

Output is a number representing the % of receiving depot share that should be transferred. Compute the transfer quantity (TQ) as follows:

Let X = table value or interpolated value. Then

$$TQ = \frac{X}{100} (A)(D)(AMD)$$

where

A = world wide assets (Purpose A Cond A)

AMD = forecasted world wide average monthly demand

D - as defined above

The actual quantity should be reduced by on hand assets at the receiving depot. Also, conditions imposed in Chapter 2 should be applied.

Linear interpolation is necessary when the computed values for YZ, DF or D are other than the value given in the table. An example follows.

Example

Assume that from the steps so far we determined that Red River is the potential shipping depot and New Cumberland is the sole potential receiving depot. Our computations give

$$YZ = 36$$

$$DF = 7$$

$$D = .2$$

The correct table in this instance is Table 1.

Since YZ falls between 30 and 50 we will work with numbers YZ = 30 and YZ = 50. Also, since DF falls between 5 and 17 we will work with the first 2 rows of numbers in these YZ groups. Finally, since D falls between .1 and .5 we will work with the first 2 columns for D.

1. For YZ = 30 and DF = 5

a. For D = .1 table value is 27

b. For D = .5 table value is 39

c. For D = .2 interpolated value is 30, as is computed below.

$$27 + (39-27)\left(\frac{.2-.1}{.5-.1}\right) = 30$$

2. For YZ = 30 and DF = 17

a. For D = .1 table value is 63

b. For D = .5 table value is 72

c. For D = .2 interpolated value is 65

$$63 + (72-63)\left(\frac{.2-.1}{.5-.1}\right) = 65.25 \text{ which rounds to } 65$$

3. For YZ = 30, D = .2, DF = 7 interpolated value is 47.5

$$\frac{30 + 65}{2} = 47.5$$

Note: Interpolation on DF is a simple average of the 2 numbers.

Interpolate for DF using the following rules:

- a. If $DF < 5$, do not interpolate. Simply use number corresponding to $DF = 5$.
 - b. If $5 \leq DF < 9$, interpolate using numbers corresponding to $DF = 5$ and $DF = 17$.
 - c. If $9 \leq DF < 17$, do not interpolate. Simply use numbers corresponding to $DF = 17$.
 - d. If $17 \leq DF < 63$ interpolate using numbers corresponding to $DF = 17$ and $DF = 63$.
 - e. If $DF \geq 63$, do not interpolate. Simply use numbers corresponding to $DF = 63$.
4. For YZ = 50 and DF = 5
- a. For D = .1 table value is 53
 - b. For D = .5 table value is 66
 - c. For D = .2 interpolated value is 56

$$53 + (66-53)\left(\frac{.2-.1}{.5-.1}\right) = 56.25 = 56$$

5. For YZ = 50 and DF = 17

- a. For D = .1 table value is 88
- b. For D = .5 table value is 91
- c. For D = .2 interpolated value is 89

$$88 + (91-88)\left(\frac{.2-.1}{.5-.1}\right) = 88.75 = 89$$

6. For YZ = 50, D = .2, DF = 7 interpolated value is

$$\frac{56 + 89}{2} = 72.5$$

7. For YZ = 36, D = .2, DF = 7 interpolated value is determined using results from steps 3 and 6.

$$47.5 + (72.5-47.5)\left(\frac{36-30}{50-30}\right) = 55$$

Thus, the final result is 55. Call this X.

TABLE 1: Move from Red River to NCAD

YZ	DF	% Demand in Receiving Depot (D)		
		.1	.5	.9
10	5	4	6	9
	17	25	34	46
	63	48	56	71
30	5	27	39	65
	17	63	72	89
	63	80	85	94
50	5	53	66	89
	17	88	91	98
	63	98	98	99
90	5	92	95	99
	17	116	110	102
	63	118	112	103
200	5	145	121	104
	17	100	100	100
	63	100	100	100
1000	5	100	100	100
	17	100	100	100
	63	100	100	100

TABLE 2: Move from RRAD to SHARPE

YZ	DF	% Demand in Receiving Depot (D)		
		.1	.5	.9
10	5	4	5	9
	17	24	32	46
	63	46	55	71
30	5	21	34	64
	17	56	66	87
	63	75	80	93
50	5	40	55	86
	17	75	82	95
	63	89	91	97
90	5	63	76	95
	17	95	96	99
	63	102	101	100
200	5	92	95	99
	17	116	109	102
	63	100	100	100
1000	5	122	110	102
	17	100	100	100
	63	100	100	100

TABLE 3: Move from SHARPE to NCAD

YZ	DF	% Demand in Receiving Depot (D)		
		.1	.5	.9
10	5	5	8	15
	17	28	37	56
	63	50	58	77
30	5	24	39	75
	17	59	69	90
	63	76	82	94
50	5	38	56	88
	17	73	82	95
	63	88	90	97
90	5	56	72	94
	17	88	92	98
	63	98	98	99
200	5	73	85	97
	17	102	101	100
	63	106	104	101
1000	5	89	94	99
	17	100	100	100
	63	100	100	100

TABLE 4: Move from SHAD to READ

YZ	DF	% Demand in Receiving Depot (D)		
		.1	.5	.9
10	5	0	1	2
	17	12	18	27
	63	31	40	55
30	5	5	11	27
	17	28	40	67
	63	48	59	81
50	5	9	20	58
	17	37	51	81
	63	57	67	88
	5	15	33	79
	17	46	61	89
	63	64	74	92
200	5	22	45	87
	17	56	70	92
	63	72	81	95
1000	5	31	56	91
	17	64	77	95
	63	79	85	96

TABLE 5: Move from NCAD to SHAD

YZ	DF	% Demand in Receiving Depot (D)		
		.1	.5	.9
10	5	2	5	9
	17	21	30	46
	63	43	52	71
30	5	14	26	62
	17	44	57	84
	63	64	72	90
50	5	22	40	81
	17	56	68	91
	63	73	80	94
90	5	30	51	88
	17	64	76	94
	63	79	85	96
200	5	43	64	93
	17	76	85	97
	63	88	92	98
1000	5	53	73	95
	17	85	90	98
	63	93	96	99

TABLE 6: Move from NCAD to READ

YZ	DF	% Demand in Receiving Depot (D)		
		.1	.5	.9
10	5	0	0	0
	17	5	7	11
	63	20	27	38
30	5	0	2	5
	17	12	19	36
	63	30	41	63
50	5	2	4	16
	17	17	27	55
	63	35	47	74
90	5	2	9	43
	17	21	35	73
	63	41	54	82
200	5	5	16	72
	17	25	43	82
	63	46	59	87
1000	5	7	24	82
	17	31	50	87
	63	50	64	90

APPENDIX B
IDT FORTRAN PROGRAM

```

PROGRAM TRAN(INPUT,TAPE2=INPUT,OUTPUT)
DIMENSION IRIC(3),D(3),S(3),DEM(3),AA(3),DTH(3)
DIMENSION COEF(3),LN(3,2,53),LNF(3,2,53),U(3,2,53)
DIMENSION F(2,53),KOPT(2),SAY(2),AA(3),DAMD(3)
DIMENSION XMONTHS(3),BUFFER(3)
ITDATA=2
C
      READ*,CFWWA,CFDEPA,CFTH,CFSLM
C
C   CFWWA,CFDEPA,CFTH,AND CFSLM ARE CONTROL PARAMETERS
C
      READ*,AA,D,DTH
      READ(2,998)IRIC
      FORMAT(3A3)
      READ*,AMD,ARSIZE,LAM,WEIGHT,CUBE
      DO 99 J=1,2
        KOPT(J)=0
        LAM(J)=0.
        ASSETS=0.
C
C   DETERMINE TRANSFER ELIGIBILITY AND SHIP RECEIVE DEPOTS
C
      M1=0
      M2=0
      TH = (DTH(1)+DTH(2)+DTH(3))/3.
      IF (TH.GT.12.) TH=12.
      DO 100 J=1,3
        DAMD(J)=D(J)*AMD
        ASSETS=AA(J)+ASSETS
        BUFFER(J)=AA(J)-TH*DAMD(J)
        XMONTHS(J)=AA(J)/DAMD(J)
        IF (ASSETS.GE.CFWWA*AMD) M1=1
        IF (AA(J).LE.CFDEPA*DAMD(J)) M2=1
      100 CONTINUE
      IF (M1.EQ.1.AND.M2.EQ.1.AND.TH.GE.CFTH) GO TO 105
      GO TO 999
      105 J1=1
      J2=1
      J3=1
      DO 101 J=2,3
        IF (BUFFER(J).GT.BUFFER(J2)) J2=J

```

```

      IF (XMONTHS(J).EQ.XMONTHS(J1).AND.D(J).GT.D(J1).AND.J2.NE.J) J1=J
      IF (XMONTHS(J).LT.XMONTHS(J1)) J1=J
101  CONTINUE
      IF (J1.EQ.J2) GO TO 999
C
C  NUMREC SET TO NO. OF POTENTIAL RECEIVING DEPOTS
C
      NUMREC=0
      DO 102 J=1,3
      IF (J.EQ.J2) GO TO 102
      IF (XMONTHS(J).GE.TH-1.) GO TO 102
      NUMREC=NUMREC+1
102  CONTINUE
C
C  PICK ASSETS AND DEMANDS FOR SHIP AND RECEIVE DEPOTS
C
      A(1)=A(1)
      A(2)=A(2)
      DEM(1)=DEM(1)
      DEM(2)=DEM(2)
C
C  SET LIMITS, COMPUTE COEF, PICK C-B VALUE
C
      ISW=1
10  IF (ISW.EQ.1) GO TO 100
      DO 201 J=1,2
      DO 201 K=1,33
101  F(J,K)=0.
      X1=TH*DEM(1)+A(1)
      X2=A(2)+TH*(TH/PSLN)*DEM(2)
      KMAX=AMIN1(X1,X2)/4.1
      IF (KMAX.LE.DEM(1)) GO TO 12
      IX=DEM(1)*12./52.+.5
      INCR=MAX0(1,IX)
      DO 1 J=1,2
      F=12.*DEM(J)/ARSIZE
      CALL COEFV(F,CV)
1  COEF(J)=CV
      CALL CBDATA(IRIG,ISW,J1,J2,J3,B1,B2,C1,C2)
      KMAX1=KMAX/INCR+1

```



```

C
C COMPUTE P(K) AND KOPT
C
DO 4 K=1,KMAX1
  L=1+(K-1)*INCR
  DO 3 I=1,3
    DO 2 J=1,2
      XMEAN=(TH*DEM(J)/3.)*I
      VAR=(COEF(J)*XMEAN)**2
      PP=XMEAN/VAR
      IF(PP.GE.1)PP=.9999
      R=XMEAN*PP/(1.-PP)
      Q=1.-PP
      VRA(1)=L
      XRA(2)=1+Q*1.-L
      IF(J.EQ.1)X=Q
      CALL NEGW(R,Q,PP,X,W)
      CALL NORM(W,X)
      EN(1,J,K)=1.-X
      ENP(1,J,K)=EN(1,J,K)
      IF(1.EQ.1)GO TO 2
      ENP(1,J,K)=EN(1,J,K)+EN(1-1,J,K)
    CONTINUE
    Z1=ENP(1,1,K)*ERF(1,2,K)
    Z1=ENP(1,1,K)+EN(1,2,K)
    IF(Z1.EQ.0.)Z1=.000001
    U(1,1,K)=ENP(1,1,K)*(Z2/Z1+1.-EN(1,2,K))
    U(1,2,K)=ENP(1,2,K)*(Z2/Z1+1.-EN(1,1,K))
    DO 5 J=1,2
      P(J,K)=U(J,K)+U(1,J,K)
    CONTINUE
    COST=WEIGHT*KC1/2000.+K*WEIGHT*KC2/2000.+LAM*KB2/365./NRSIZE)*M(2,K)
    BENEFIT=(WEIGHT*KC2/2000.+LAM*KB1/365./NRSIZE)*P(1,K)
    S(K)=BENEFIT-COST
    IF(S(K).LT.0.)GO TO 11
    IF(INCR.NE.1)GO TO 28
    SAV(ISW)=SAV(ISW)+S(K)
    GO TO 4
  CONTINUE
  IF(K.EQ.1)GO TO 4
  SAV(ISW)=SAV(ISW)+INCR*(S(K)+S(K-1))/2.
  CONTINUE
11 KOPT(ISW)=L-INCR/2
  IF(K.EQ.1)KOPT(ISW)=0
  IF(S(K).GE.0.)KOPT(ISW)=KMAX
  IF(SAV(ISW).LT.21.)KOPT(ISW)=0.
  ONHAND=ASSETS-KOPT(1)-KOPT(2)
  REQ=2.*AMD
  IF(ONHAND.GE.REQ)GO TO 16
  KOPT(ISW)=KOPT(ISW)-(REQ-ONHAND)
16 CONTINUE
  IDEM=DEM(1)
  IF(KOPT(ISW).LE.IDEM)KOPT(ISW)=0

```

```

C
C SET VALUES FOR SECOND RECEIVING DEPOT
C

```

```

      IQ=KOPT(ISW)
      IF (ISW.EQ.2) GO TO 12
      IF (NUMREC.EQ.1) GO TO 12
      ISW=2
      DO 108 J=1,3
      IF (J.EQ.J1.OR.J.EQ.J2) GO TO 108
      A(1)=AA(J)
      DEM(1)=DAMD(J)
      JS=J
108  CONTINUE
      GO TO 10

```

```

C
12  CONTINUE
      PRINT*,IRIC,AA,D,DTH
      PRINT*,CPWWA,CPDEFA,CPTH,CPSLM
      PRINT*,ABD,ARSIZE,LAN,WEIGHT,CUBE,TH
      PRINT*,KOPT,SAV,J1,J2,J3
      GO TO 999
      END

```

```

C
C
      SUBROUTINE NEDW(R,Q,FP,X,W)
      IF (R.EQ.0) R=.000001
      XPLUS=X+1.
      RAD1=(R*Q/(FP*XPLUS))**(1./3.)
      RAD2=RAD1*RAD1
      Y=(9.*R-1.)*RAD1/R+(9.*X+8.)/XPLUS
      Z=RAD2/R+1./XPLUS
      W=Y/(3.*SQRT(Z))
      RETURN
      END

```

```

C
C
      SUBROUTINE NORM(W,X)
      IF (ABS(W).LE.8.) GO TO 5
      Z=0.
      X=1.
      IF (W.LE.0.) X=-0.
      RETURN
      IF (ABS(W).GT.1.00001) GO TO 10
      Z=.39894228
      X=.5
      RETURN
10  Z=.39894228*EXP(-W*W/2.)
      Y=W
      IF (Y.LE.0.) Y=-Y
      F=1./(1.+2316419*Y)
      X=1.-241*(.31938153+T*(-.35656378+T*(1.7814779
      X+T*(-1.821256+T*1.3302744))))
      IF (W.LE.0.) X=1.-X
      RETURN
      END

```

```

C

```

C

```

SUBROUTINE COEFV(F,CV)
IF(F.LT.5.)PER=1.286
IF(F.GE.5.AND.F.LT.8.5)PER=1.019
IF(F.GE.8.5.AND.F.LT.16.5)PER=.792
IF(F.GE.16.5.AND.F.LT.32.5)PER=.656
IF(F.GE.32.5.AND.F.LT.62.5)PER=.575
IF(F.GE.62.5.AND.F.LT.122.)PER=.469
IF(F.GE.122.)PER=.409
IF(PER.LE.0.5)GAM=1.27
IF(PER.GT.0.5.AND.PER.LE.0.8)GAM=1.33
IF(PER.GT.1.)GAM=1.52
CV=GAM*PER
RETURN
END

```

C

C

```

SUBROUTINE CDDATA(IRIC,ISW,J1,J2,J3,R1,R2,C1,C2)
DIMENSION IRIC(3)
K=J1
IF(ISW.EQ.2)K=J3
IF(IRIC(J2).EQ."BR4".AND.IRIC(K).EQ."AN5") GO TO 1
IF(IRIC(J2).EQ."BR4".AND.IRIC(K).EQ."AQ5") GO TO 2
IF(IRIC(J2).EQ."AQ5".AND.IRIC(K).EQ."AN5") GO TO 3
IF(IRIC(J2).EQ."AQ5".AND.IRIC(K).EQ."BR4") GO TO 4
IF(IRIC(J2).EQ."AN5".AND.IRIC(K).EQ."BR4") GO TO 5
IF(IRIC(J2).EQ."AN5".AND.IRIC(K).EQ."AQ5") GO TO 6
1
R1=7.0517
R2=1.835
C1=226.
C2=269.
RETURN
2
R1=6.9122
R2=3.974
C1=278.
C2=402.
RETURN
3
R1=6.9122
R2=3.974
C1=278.
C2=402.
RETURN
4
R1=6.9122
R2=3.974
C1=278.
C2=402.
RETURN
5
R1=1.835
R2=7.0517
C1=226.
C2=269.
RETURN
6
R1=7.1828
R2=6.8634
C1=360.
C2=608.
RETURN
END

```

..

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- 8 Direct Support System and Air Line of Communication (ALOC) Performance Evaluation (RCS CSGLD 1557). Monthly reports from January 1977 through February 1979.

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